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Research Article

A Single Stage Soft Switching Boost Fly Back Pfc Converter, Cuk-Sepic Pfc Rectifier To Determine Its Efficiency

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Abstract

The role of ac-dc rectifier associated with power factor correction (PFC) is viable in nature and it as unavoidable due to its severe action upon voltage correction, harmonics reduction, filtering unit. Nevertheless Most of the ac-dc conversion cannot dopower factor correction. This paper dealt with several PFC converters in addition with circuit operation and its efficiency. This review can visualize single phase boost PFC converter, single stage soft switching boost fly back PFC converter, bridgeless SEPIC PFC rectifier, SEPIC-CUK PFC rectifier. Among lot of PFC rectifiers to achieve higher power factor, even though efficiency has been seen as major concern. The load performance depends upon the rate of voltage delivered to it. Higher the output voltage with lower input range only can demonstrate how much amount of power lost and consumed by active and passive elements. As from above statement the efficiency of a converter is examined.

Keywords: Power Factor Correction (PFC); Single Phase Boost PFC Converter; Single Stage Soft Switching Boost Fly Back PFC Converter; Bridgeless SEPIC PFC Rectifier;-SEPIC- CUK PFC Rectifier.

I.INTRODUCTION

Over a past the rectifiers are used only for ac-dc conversion. Day-by-day the enlargement of technology in power electronics, contribute power conversion also. Normally ac-dc rectifiers are known for dc production only. It does not look upon the output voltage quality. Without proper stabilization the voltage is not driven to the load. Because variation in load cause fluctuation or else any unwanted signal or variation in load can also have ability to weaken the load. It interrupt load. Thus the need of stabilization is more essential.

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Looks upon inverter portion, circuit needs passive filters to make constant output voltage without any oscillation and reduction in harmonics. Likewise rectifier also requires some specification within it to regulate the voltage and without any changes in power factor. Even half bridge and full bridge rectifier supply input and delivers output voltage as much as possible including power loss caused by diode. The diode cannot act until the voltage reaches above 0.7 volt. Along power conversion diode emits voltage in the form of diode. These actions further decrease the efficiency.

To overcome these problems a converter circuit is merged with diodes to perform these action nowadays. Most of the ac-dc converters reduce diode as much as possible. Instead of diode they prefer switches. Because switches acts upon whatever the gate pulse given to it. The pulse determines the on/off time of switch. But a ac-dc rectifier with more number of switches down come the efficiency. The switches are preferred for incremental output voltage even though N number of switches can cause severe voltage stress. The switching stress in turn, combines with diode to increase losses. During ac-dc rectifier choosing, it is essential look upon number of active and passive components used in it. In this comparative study on various rectifier topologies are analyzed.

Apart from increase in output voltage the power factor becomes major one. The power factor determines the load consumption alone. The system running with low power factor it needs more power to achieve high efficiency. The system with limited internal current to achieve efficiency maximum, it would need higher power factor. The power factor ranges up to 1. With regularities in circuit topology the pfc correction rectifiers are designed.

The power factor correction rectifier described in this project is: Single Phase Boost PFC Converter; Single Stage Soft Switching Boost Fly Back PFC Converter; Bridgeless SEPIC PFC Rectifier; SEPIC-CUK PFC Rectifier. All the above rectifiers possess minimal number of active and passive elements. Even though output voltage of individual rectifier, shall vary due to its internal losses. The inter combined action of several rectifiers with one another also discussed later. In this paper both rectifier operation and efficiency is calculated.

II.LITERATURE REVIEW

Hongbo Ma et.al, have a clear idea about bridgeless SEPIC pfc converter in addition with a diode and inductor at output side. The losses occur to switching action is said to be less and unnecessary capacitor coupling loop is removed. Instead of large size filtering unit the circuit topology can have enough potential to filter it and reduce the cost is represented in [1].

William de J. kremes et.al, established a single phase hybrid step-up discontinuous SEPIC rectifier. The proposed should evolve a split capacitive output voltage with reduction in harmonics and distortion at output stage; inter combines three stage switching action with switched capacitor in [2]. A total of 400 volt output voltage as split into 200 volt by the insertion of 220 volt input voltage. The switching frequency becomes 50 hertz in prototype.

A PWM boost rectifier for DC rail was proposed by J. C. Salmon et.al. The specified is implemented for single phase and three phase ac supply. Fetching inductor at AC input or DC output side to perform split operation. Thus the rectifier looks upon both 1 and 3 phase rectification and it is described in [3].

Ahmad J. Sabzali et.al, has given a novel methodology in [4] rectification associated with power factor correction operation. It correlatesSEPIC with CUK PFC rectifier. This advancement can make more viable and a steady state power flow through load. The input bridge diode is replaced through combination of semiconducting devices. These switches are tuned at regular interval with low gate pulse. It replaces inconvenience in conventional SEPIC-CUK combination. At rated time delay both switches are operated. With reduction in switching stress the output voltage attained regularly.

Hsien Yi Tsai et.al, proposed a bridgeless PFC circuit comprising of two unidirectional diodes, resonant inductor to maintain low switching losses. In [5] a prototype has been designed with rated voltage of 100 Khz, 600 watts respectively.

Chien Ming Wang et.al, designed a single phase high gain boost rectifier leading to unity power; zero voltage switching further examines and shown how much amount of voltage consumed by electrical devices to perform rectification and total loss within it. This method [6] is well suited for zero voltage switching in main and sub switches including passive switches. This method become more reliable and better in comparison with conventional one described in paper. The output voltage tends to be 400 volt respect to220 volt input voltage; power factor range up to 0.99.

Radha Kushwaha et.al, proposed a pfc converter for electric vehicle battery charging. A combination of zeta-SEPIC converter followed by fly back converter based battery charging is established in [7]. Even though there is a combination of two circuit topologies available, but the inductor at input side is common for both to perform independently. This thing allows the pfc rectifier to achieve more efficiency when compared to other methods.

Joe C.P. Liu et.al, dealt with higher frequency, low current harmonics based ac-dc converter. This converter is chosen due to its distinct characteristics. They are low switching stress, reduction in noise level, designed with less number of active and passive components. Likewise [7], the converters design [8] also posses two converter section.

Hao Zhang et.al, proposed zeta converter based ac-dc pfc correction converter. Depending upon the gate pulse given to it the circuit performance is determined in [9].

Hong Tzer Yang et.al, designed a single phase cuk pfc rectifier in [10]. This rectifier converts high voltage into low voltage and it is well suited for low power applications.

III.POWER FACTOR CORRECTION RECTIFIER

The various power factor correction rectifier dealt in this paper is listed one by one.

Single Phase Boost PFC Converter:

It accomplishes bridgeless interleaved boost power factor correction methodology mainly used for charging batteries. Whenever the battery voltage attains low, it boosts the voltage and reduces charging time.

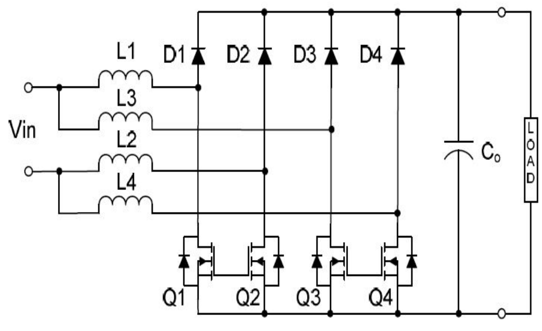

Fig.1.represents single phase boost pfc converter.

The circuit operation is divided into positive and negative half cycle. During positive cycle Q1 and Q2 conducts current. The current flows through L1, L2 and energise completely. During turn off condition the energy stored energy moves towards load through D1, returns to input port through body diode at Q2. With 180 degree switch Q3 is operated.

During negative cycle Q2, Q4 starts to conduct and input current energise L2, L1. When switches are at rest condition D2 creates a path for discharging of L2, L1 towards output. It returns through body diode attached with Q1.

Single Stage Soft Switching Boost Fly Back PFC Converter:

The s6 pfc converter can have auxiliary winding to achieve soft switching and limit the current harmonics oriented with input voltage. The belonging circuit contained with semiconductor devices are ideal; the voltage at DC link capacitor remains stable. Due to sinusoidal input voltage the frequency at input voltage tends to be high. By adding auxiliary winding in series with boost inductor, the internal current harmonics decreases.

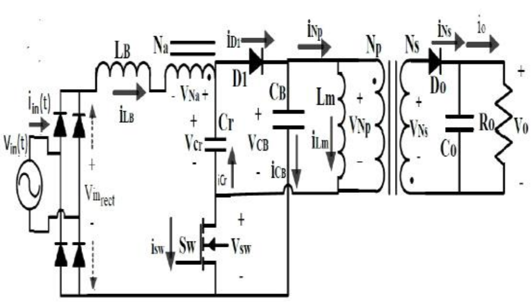

Fig.2. Single Stage Soft Switching Boost Fly Back PFC Converter.

Its operation is broadly classified into seven stages.

In mode 1, SW turned on; D1 & D0 become reverse biased. L_B charged through the input current. The capacitor C_T charged through the inductor current. The diode D1 conducts in forward bias. The inductor accumulates charge until turn off the switch as represented in mode 2. The mode 3 switch off the supply voltage and inductor starts discharging. At mode 4 D0 is forward biased. The current through diode reaches zero when the inductor voltage is equal to capacitor current (iCr).

The mode 5 represents discontinuous conduction mode because the energy at L_B and Lm completely discharged completely; D1 would not conduct throughout the whole cycle. Mode 6 ends with the completion of discharging occur in $L_{B..}$ Otherwise it will continue. In mode 7 the charging of capacitor is performed slowly. The repetition of this process supply continuous power to the load.

Bridgeless SEPIC PFC Rectifier

The bridgeless SEPIC pfc converter is chosen for reduction of distortions in input voltage. Sometimes the input voltage may not be sinusoidal. At that situation this pfc rectifier become more effective than ordinary one. Initially it boost the voltage range and after that it purifies the voltage and maximise the power factor. With single switch the circuit topology become viable and a better solution for power compensation. High gain with low input voltage demonstrates the efficiency as well as expected output voltage. The power factor nearer to unity through this pfc conversion. The modes of operation imply the circuit operation in a simple manner.

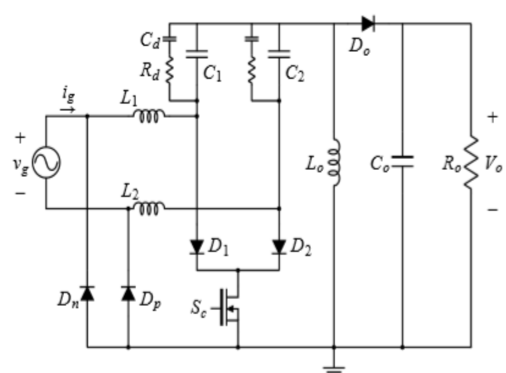

Fig.3.visualizes bridgeless SEPIC PFC Rectifier.

In mode 1 Sc is switched on; D_0, D_2, D_n are biased reverse. L1 charged completely and C1 attains charging through L0. The stability can be enlarged by resonant damping. The energy transfer happens between C1, C2, and L2. C2 share charge with C1.In next cycle the inductor L0 does not correspond with input voltage. Thus C0 maintains a steady state power flow at resistive load. Only D0 accept power flow through this from storage elements to energies the resistive load.

SEPIC-CUK PFC Rectifier

The combination of SEPIC-CUK converter is designed to perform zero voltage switching in relation with incremental power factor. The advantages are low inrush current at start and end; ease to isolate the transformer portion, low current harmonics.

The switch Q1 and D_P is at conducting mode. At this stage, voltage at three inductors gradually increasing without any interrupts. The diode at output side become reverse biased by reverse voltage occurs in the circuit. After this, switch becomes turned off, also the inductor current decreasing. The inductors current il1 and il2 flows through D_P. In next state il3 flown through Dp. C1 is energised through iL1. Similarly il2 energise C2. By these actions the addition of voltage three inductors becomes zero. Whether the circuit could not perform well the body diode across switch Q2 starts to conduct. To apply reverse voltage across switches, it turns them into reverse blocking capable one. Hence unidirectional power conducting switches are preferred. These make power flow continuously towards load.

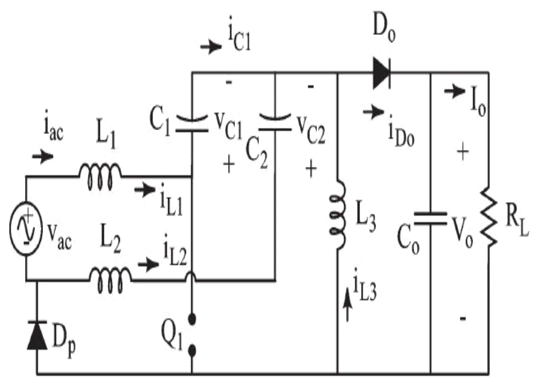

Fig.4. SEPIC-CUK PFC Rectifier

IV.RESULT AND DISCUSSION

The solution to every problem in electrical circuit is plenty. Nevertheless a perfect solution is identified only through rated input voltage and estimated output voltage which holds simple circuit configuration; ease to analyze the fault; number of active and passive at less number. With reduction in complexity of operation the pfc rectifier is determined whether it suitable for high power or low power applications. From the above section the working model of every pfc rectifiers are analyzed and similarities in it also described. All the above circuits are designed for pfc and boosting the voltage at severe circumstances. These do their function well but some limitations will be there in it such as low power, high powered application, low and high ripple, and operation under continuous and discontinuous conduction. Regarding with the above analysis this paper prefer bridgeless SEPIC pfc converter. Their inherent and adequate capabilities further strengthen the pfc rectifier. Thus the below table witnessed the circuit configuration with input/output voltage characteristics.

The analytical study of rectifier’s component details are listed in below table.

Name of the component	Boost PFC Converter	Boost Fly Back PFC Converter	Bridgeless SEPIC PFC	CUK-SEPIC PFC Rectifier
No. of switches	4	1	1	1
No. of diodes	4	2	3	6
No of capacitor	1	3	3	3
No. of inductor	4	3	3	3

The amount of power flown through the circuit and total amount of retrieved as output is described below.

	Boost PFC Converter	Boost Fly Back PFC Converter	Bridgeless SEPIC PFC	CUK-SEPIC PFC Rectifier
Input	240V	110V	120V	100
Output	400V	40V	220V	48

Through above knowledge the efficiency is determined. The bridgeless SEPIC pfc rectifier posses 120 volt as input and it reaches 22o volt during boost operation and 80 volt as buck converter. This survey is enough to witness bridgeless SEPIC pfc is enough to do pfc .

V.CONCLUSION

The novelties of several rectifiers are concluded through comparative study. Each rectifier individual and combined performance with its unique characteristics is categorized in this paper. Thus how much amount of loss and gain is differentiated through the input and output voltage at the circuit is estimated. The theoretical explanation about converter demonstrates the operating principle behind rectification. As from the above reading the SEPIC based PFC rectifier is represented as efficient and reliable method. This employs only one switch at the input stage. The passive elements at output stage stores the total power supplied by the circuit. From the above point of view the SEPIC PFC rectifier is well suited for high power conversion.

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